§17. Calibration of Fast Ion Flux Measured by a Directional Probe in CHS

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Recently a fast ion measurement using a hybrid directional probe (HDP) was developed [1]. Both probe current and heat flux are obtained at the same point and same period. In this way, we can basically obtain absolute value of fast ions. However secondary electrons produced by attack of fast ions to the probe surface escape toward the plasma and enlarge the probe current. So calibration of HDP is necessary to measure absolute value of fast ions.

For the calibration of the HDP, a NB and a mixing beam (neutral hydrogen and proton), of which local powers on the probe were estimated by beam profile, are injected to the HDP. The temperature of the probe head increases with the total power of the beam, which is shown in Fig. 1. The linear relation was obtained clearly and the conversion factor from the temperature increase to energy density is 6.8×10^4 J/m^2/degree.

The probe current with the probe bias voltage of -120V was measured. For the H beam case, the probe current I_p is proportional to NB current attacking the probe surface I_{NB}, which is shown in Fig. 2, where the intensity of NB was expressed by the unit of ampere estimated as a single-charged beam. The yield of secondary electron emission due to neutral hydrogen beam is 1.8 ± 0.4. The difference of probe currents between neutral hydrogen beam case and mixture beam case corresponds to the probe current produced by the proton beam, which consists of the proton beam current and secondary electron current due to the proton impacts. This current was compared with the estimated proton current obtained by the neutralization efficiency of 60% of the BL2, which is measured by the thermal probe method using this HDP. The secondary electron emission yield for proton beam was obtained as a function of beam particle energy, which is shown in Fig. 3. The secondary electron yield of proton beam depends on beam energy while that of hydrogen beam does not. This secondary electron yield can explain well the results of fast ion measurements in CHS.

References

[1] K. Nagaoka, *et al.*, Plasma Fusion Res. 1 (2006) 005.

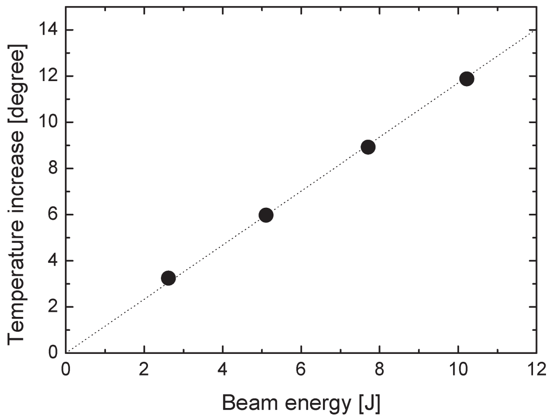

Fig. 1 The temperature increase of the probe tip as a function of total Beam Energy attacking the probe tip.

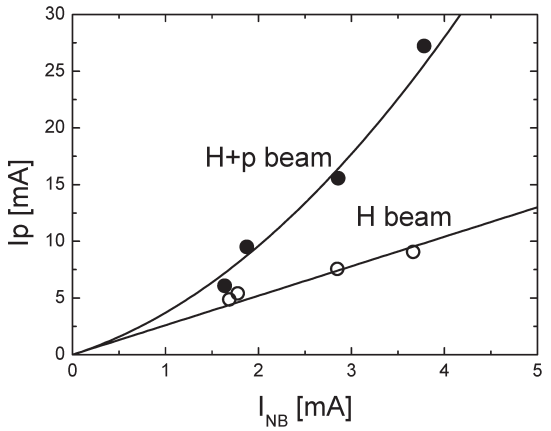

Fig. 2 The probe current as a function of neutral beam current attacking the probe tip.

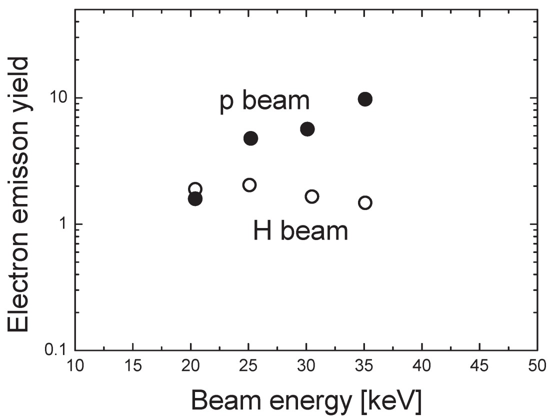

Fig.3 The secondary electron emission yield of proton beam and hydrogen beam as a function of beam energy.